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ABSTRACT

The differences in responses of grade 6 boys and girls to selected items on a standardized test are examined. Data are the responses of approximately 36,000 children during 1978-79 to two test forms of the California Assessment Program's Survey of Basic Skills: Grade 6 (SBS:6). Performance on specific arithmetic items is studied and involves the concepts of whole numbers, fractions, and decimals. These skills are tested both as simple computations and as story problems. Of the six problems presented in this study, three showed sex differences in the patterns of responses; boys were more likely than girls to answer the story problems correctly after missing computation items requiring the same skills. From these two forms, the indications were that girls are selecting the same distractors regardless of performance on the computations. In contrast, boys' responses seemed to depend upon success or failure on the computations. Analysis of distractors does not explain why boys and girls differ in their responses. However, such analyses can be useful in identifying the areas in which the sexes differ. (RL)

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Sex Differences in Sixth Grade Children's Problem Solving[1]

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Many researchers have found sex differences in mathematics performance (Benbow & Stanley, 1980; Hilton & Berglund, 1974; Maccoby & Jacklin, 1974; Backman 1972). Most studies of sex differences have been concerned with total test performances of males and females; usual statistics reported are mean number of items correct for each sex.

It is apparent in several studies that males and females excel in different areas of mathematics. For example, Fennema and Sherman (1978) report mean scores for boys and girls from four schools. At the sixth grade, girls generally scored higher than boys on tests of math computation while boys obtained higher scores than girls on tests of application and problem solving.

Marshall (1981) also found evidence that boys and girls at the sixth grade excel in solving different types of problems. Girls are better on items of computation, and boys are more successful on story problems. These differences suggest that the sexes may be approaching problem solving with different strategies, with one set of strategies being more appropriate for certain problems and another set being suitable for other problems.

This paper examines the differences in responses of sixth grade boys and girls to selected items on a standardized test. Several questions are of interest. Are the children approaching the problems with identifiable strategies? Are the strategies similar? In particular, are the children erring in similar ways and therefore choosing the same incorrect responses?

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The unit of comparison between the sexes is not the number of items correct on the test. Rather, the interest here is in the patterns of responses to selected items. For example, one can question whether, given certain items correct, the sexes are equally likely to solve another problem correctly. One can also question whether those who err given other items correct are selecting the same wrong responses.

Data Source

The data reported here are the responses of approximately 36,000 children to two test forms of the Survey of Basic Skills: Grade 6. Roughly 9,000 girls and 9,000 boys responded to each form. The Survey is a multiple-choice achievement test administered annually by the California Assessment Program of the California Department of Education. The responses analyzed here were made in the academic year 1978-79.

The Survey of Basic Skills was designed to sample the achievement of sixth grade children in California. Results are provided for school, school district, and state levels. There are sixteen 30-item test forms; each contains items of reading, written expression, spelling, and mathematics.

Performance on specific arithmetic items on two test forms is studied in this paper. The items of interest involve the concepts of whole numbers, fractions, and decimals. These skills are tested both as simple computations and as story problems. For each test form, one story problem and two related computations are examined.

Many results given here are simply percent correct or percent incorrect for each sex on each problem. With the large sample studied, any differences in proportion correct are statistically significant. Of greater interest is the magnitude of the difference.

Item Analysis

The six items discussed in this paper are given with their respective response options in Table 1. Items 1-3 are taken from one test form of the Survey of Basic Skills: Grade 6 and items 4-6 are

taken from a second form. The probability of success for boys and girls in solving each problem is given in Table 2. Girls are more likely than boys to answer all four computations correctly. Boys are more likely than girls to answer the two story problems correctly.

The probabilities of Table 2 lend support to the suggestion that boys and girls excel in different types of problem solving. At issue now is the question of whether girls and boys who err on these problems do so in similar ways. That is, are they choosing the same incorrect responses? To investigate this issue the distributions of incorrect responses for males and females on each item were compared.

Computations

Item 1. Although most children answer Item 1 correctly, roughly one thousand children answered incorrectly. Boys and girls do choose different distractors. Boys are more likely than girls to select response (c) while girls are more likely to select (b). These responses reflect similar mistakes in 'carrying', but the errors occur in different columns.

These results have been confirmed from data gathered in 1976-77 and 1977-78. Responses from approximately 18,000 children in each year to this item have the same pattern as that described above. Girls and boys err in different ways, or at least, on different parts of the item. The differences in response on this item are puzzling. The choice of distractor may indicate that the boys and girls are somehow viewing the problem in different ways.

Item 2. There are no differences in males' and females' responses to the subtraction item. The predominant incorrect choice for both sexes is 'None of these'. The second most popular distractor is option (b). This selection indicates incorrect alignment of the parts of the problem: decimal positions are ignored. Slightly more girls than boys choose this response (37 percent and 33 percent respectively).

Item 4. On this subtraction problem, there are indications of sex differences. Of those children answering incorrectly, both sexes select response (c) most often. However, the second most popular response by boys is option (a) while girls select (b). Boys are

almost equally divided between responses (a) and (c), answering 33 percent and 35 percent respectively. Girls clearly prefer option (c) and then select (b), with 39 percent selecting the former and 32 percent choosing the latter. Again, these results have been confirmed by the data of 1976-77 and 1977-78.

Item 5. There are no apparent differences in the sexes' responses to Item 5. Response (c) is the most frequent choice, and approximately 45 percent of each sex select it. Option (d) is the next choice, with about 35 percent of each sex choosing it.

Unfortunately, the results for Item 5 may not be as reliable as they seem. Consider the response options given for this item in Table 1. Response (c) reflects addition, response (d) indicates division. The correct response (b) can be obtained by either of the two remaining primary operations. That is,

$$4 \times 4/5 = 4 - 4/5 = 3\ 1/5\ .$$

The most chosen distractor corresponds to addition of 4 and 4/5. It is not unlikely that some children also subtract 4/5 from 4. Errors from this operation are not reflected in the responses; indeed, the answer obtained in this erroneous manner coincides with the correct response.

Story Problems

Item 3. Males and females respond to the first story problem very similarly. The probability of success is nearly identical (.5188 for males and .5100 for females). Both sexes select distractor (a) most frequently, with girls more likely than boys to choose it (42 percent of all girls answering incorrectly compared with 44 percent of all boys answering incorrectly). Both sexes also select distractor (c) with high frequency. Roughly 34 percent of the boys and 30 percent of the girls choose it.

Item 6. Responses to the second story problem suggest sex differences in problem solving. Females overwhelmingly select response (a). Of all possible choices including the correct option, 33 percent of the girls select (a) compared to 29 percent selecting (c). An additional 24 percent select (d). Of the males, 37 percent answer correctly, and about 25 percent select (a) and (d) each.

This item deserves extended discussion because the distractor choices (a) and (d) reflect different problem solving strategies. Response (a) corresponds to the first step of the solution:

$$1/2 \times 12 = 4 .$$

Response (d), on the other hand, may indicate general understanding of the problem coupled with arithmetic error. That is, one way to achieve the response is:

Step 1: $1/3 \times 12 = 3$ (incorrect)

Step 2: $12 - 3 = 9$ (correct)

The arithmetic of the first step is wrong but the logic leading to the solution '9' is appropriate. The choice of (a) suggests a misunderstanding of the problem; a response of (d) suggests arithmetic error.

Relationship Among the Items Within a Test Form

The items discussed in this paper were selected because they had particular relationships. Both of the computations on a test form require skills used in solving the accompanying story problem. One assumes that correct solution of the computation items will correlate with solving of the story problem, because the story problem requires a similar computation. Table 3 shows the probability of success on the story problems given possible correct/incorrect responses on the companion computations.

Form 1

The probability of a correct response to the first story problem (Item 3) is approximately the same for boys and girls (see Table 2). It is evident from Table 3 that the probability of success remains similar for both sexes when either or both of the computations are answered correctly. However, boys are much more likely to answer the story problem correctly given incorrect responses to both computations than are girls. That is, it appears that mastery of the skills required by the computations is more important for the girls on this item than for the boys. If the girls cannot solve the computations, they have little chance of solving the related story problem. The probability of success on the story problem given successful answers to both computations is almost 2 1/2 times greater than the probabil-

ity of success given incorrect responses to both. For the boys, the probability of success on Item 3 given success on Items 1 and 2 is about 1 3/4 times as large as the probability of success on Item 3 and failure on both computations.

A possible implication is that the computational items are not good measures of whether the boys have mastered the skills of addition and subtraction. One suspects that the skills are mastered but that the boys are more careless in their arithmetic. The rate of success for girls who miss both computations is substantially lower than that for boys. It appears that girls who err on the computations do so because they have not mastered the needed skills. If they have not mastered the requisite skills, they cannot be successful on the story problem requiring the same proficiency.

Form 2

The relationship between computations and story problem on the second form differs from that observed on the first. The probability of success on the story problem for males is .3682 and for females is .2935. It is evident from Table 3 that success on both computations is more indicative of success on the story problem for males than for females.

Compare each sex's probability of success on Item 6 given success on Items 4 and 5 with that given failure on the same items. As on Form 1, the probability for boys is approximately 1 3/4 times greater if the computations are answered correctly than if the items are missed. For girls, the probability is only 1 1/3 times larger. Recall that on the first test form, answering the computations correctly resulted in a probability for the girls that was 2 1/2 larger than that obtained when the computations were answered incorrectly. One infers that the computational skills play a more dominant role for girls on the first test form than on the second.

Item 6 poses some obstacle to girls that reduces the importance of computation skills. One might suggest that girls do not like baseball cards and that the masculine content of the item affects girls' problem solving. Other items on the Survey have more feminine content (e.g., recipe conversions in baking) but the differences in solving story problems remain. On items that cannot be solved by a

single simple arithmetic step, boys are more likely to succeed than girls.

Discussion

Of the six problems presented here, three show sex differences in choice of distractors. There are also differences in the patterns of responses; boys are more likely than girls to answer the story problems correctly after missing compuation items requiring the same skills.

Further differences in responses can be seen in a comparison of boys' and girls' answers to the story problems under the various conditions of Table 3. When both computations are answered correctly, boys who err on Item 3 select response (c) most often. Girls select (a). In all other situations, boys and girls both select (a) most often.

On the second test form, boys who miss both computations are more likely to miss Item 6 by selecting (c). Girls select (a). Boys in the other situations select (a) more often than (c), as do girls.

From these two forms, the indications are that girls are selecting the same distractors regardless of performance on the computations. In contrast, boys' responses seem to depend upon success or failure on the computations.

Analysis of distractors does not explain why boys and girls differ in their responses. However, such analyses do provide evidence that girls and boys are approaching problems in different ways and can be useful in identifying the areas in which the sexes differ. Once these areas are identified, other methods of investigation, such as protocol analysis and personal interview, may yield details about cognitive differences in problem solving strategies.

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Table 1

Items and Response Options**

A. Test Form 1

Item 1:

744
+578

(a) 1,212
(b) 1,222
(c) 1,312
* (d) 1,322

Item 2: Substract 76.8 from 462.53.

(a) 539.33
(b) 454.85
(c) 386.73
* (d) 385.73
(e) None of these

Item 3: Mrs. Jones has $158.62. She makes purchases of $5.25, $49.88, and $10.35. She earns $51.64. How much does she have now?

(a) $172.46
* (b) $144.78
(c) $41.50
(d) $13.84

Table 1 continued

B. Test Form 2

Item 4:

4003
- 209

(a) 4,794
(b) 3,894
(c) 3,804
* (d) 3,794

Item 5: 4 × 4/5 =

(a) 1 3/5
* (b) 3 1/5
(c) 4 4/5
(d) 5

Item 6: John has 12 baseball cards. He gives 1/3 of them to Jim. How many does John have left?

(a) 4
(b) 6
* (c) 8
(d) 9

**Test items are reproduced here through the permission of the California Assessment Program, California Department of Education.

*Asterisks indicate correct responses.

Table 2

Probabilities of Correct Response
to Each Item for Boys and Girls*

		Sex	
		Boys	Girls
Form 1	Item 1	.9054	.9312
	Item 2	.3963	.3999
	Item 3	.5188	.5100
Form 2	Item 4	.7830	.8101
	Item 5	.4661	.5068
	Item 6	.3682	.2935

*Items 1, 2, 4, and 5 are computations. Items 3 and 6 are story problems.

Table 3

Probability of Solving Story Problems Correctly
Given Successful/Unsuccessful Solving of Computations

	Boys	Girls
Item 3		
prob (success / correct on Item 1 and correct on Item 2)	.652	.644
prob (success / correct on Item 1 and incorrect on Item 2)	.449	.441
prob (success / incorrect on Item 1 and correct on Item 2)	.505	.492
prob (success / incorrect on Item 1 and incorrect on Item 2)	.348	.261
Item 6		
prob (success / correct on Item 4 and correct on Item 5)	.454	.331
prob (success / correct on Item 4 and incorrect on Item 5)	.320	.269
prob (success / incorrect on Item 4 and correct on Item 5)	.369	.264
prob (success / incorrect on Item 4 and incorrect on Item 5)	.262	.247